Niels Jonassen

Are Ions Good for You?

Mr. Static explores the reputed physiological effects of ions.

About a hundred years ago, it appeared as if all the important discoveries in physics happened almost simultaneously. For example, Wilhelm Röntgen discovered and developed x-rays, and Henri Becquerel and the Curies discovered radioactivity. It was soon realized that both phenomena had effects that could be put to very important use in industry, medicine, and other scientific fields.

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However, the discoverers themselves were not aware that exposure to these phenomena could pose a health hazard. Röntgen is known to have looked directly into an x-ray beam to determine whether it had any effect on the eye, Becquerel always wore a lump of pitchblende in his waistcoat pocket, and Marie Curie developed radiation damage to her hands from handling radium.

Although x-rays and radioactivity have many similarities, they are obviously very different in nature. X-rays, being associated with accelerated electrons impinging on certain metals in vacuum, are not natural phenomena, whereas radioactive processes have taken place since the first day.

It is also interesting that the common by-products (i.e., atmospheric ions or air ions) of both processes when taking place in atmospheric air were not recognized until about the same time as the discoveries of x-rays and radioactivity. It could be speculated that the cause must be known before the effect can be discovered, but this is not so. The existence of atmospheric ions could very well have been predicted a century earlier. In 1796, Coulomb had already observed that an insulated charged body would gradually lose its charge when exposed to atmospheric air. However, it was not until 1899 that Elster and Geitel and, almost simultaneously and independently, C.T.R. Wilson demonstrated the existence of mobile charge carriers in air and rightfully ascribed it as the result of radioactive decay of mostly airborne nuclides such as radon and its short-lived daughters.

The nature of air ions has been discussed at length several times in this magazine, so let it suffice to state a few simple facts.[1,2,3] Air ions are not charged molecules or atoms. They are clusters of mostly water molecules (say 12–14) around an oxygen or nitrogen molecule that has lost an electron (i.e., a positive ion), or 8–10 water molecules around an oxygen molecule that has gained an extra electron (i.e., a negative ion).

All air ions are created equal. There is no difference between the ions produced by radioactive decay of airborne materials or by cosmic rays, and the ions produced in a technical ionization system by accelerating incidental electrons to sufficiently high energies. This technical method of ionization is again, in principle, identical to what happens when the field from a thundercloud induces corona discharges from the tips of leaves or from lightning rods.

It should be stressed that ions are always created in pairs—a positive and a negative ion. In unipolar field ionizers, one polarity is automatically held back, so it appears as if only positive or negative ions are produced, but that is not so.

Ions do not live forever. They recombine with oppositely charged ions, they combine with aerosol particles, and they plate out on surfaces. Therefore, the reason for a more or less constant ion concentration of some hundred ions of each polarity per cubic centimeter (at sea level) is the constant production of maybe 5–10 ion pairs per cubic centimeter per second caused by natural radiation. So to keep a high ion concentration in a given volume, ions have to be constantly produced.

Air ions have a very important role to play in industry, namely that of neutralizing charges on insulators. In fact, the use of a bipolar mix of air ions is the only way by which the field from a charged insulator can be neutralized. The charge can never be removed, but the field from the charge can be neutralized, and that is just as good. As that problem has already been treated in detail, this article concentrates on the claims of direct or indirect effects of air ions on human beings.

Almost from the very first detection of air ions, there has been speculation about possible hygienic, physiological, or other types of effects. The first paper may have appeared as early as 1923. Very few, if any, of these first papers deserve the designation of *scientific papers*, which should only deal with properly described and properly conducted investigations. Almost all reported investigations were purely anecdotal. In my opinion, one of the reasons for this was that usually the investigations were

carried out by physicians and other laypeople without the guidance of physicists with a proper knowledge of atmospheric electricity.

For example, in the 1930s, it was rather common in Germany to treat a variety of ailments, such as asthma, bronchitis, and other airways-related problems, by letting the patients (apparently) inhale negative ions. Some of the administrants of these treatments, usually medical practitioners, reported rather astonishing results. At a certain point in these experiments, somebody had the good sense to ask a real expert to examine the ionizers to find out what they were actually doing. The all-time-ever expert on atmospheric electricity, Hans Israël, agreed to do this.[4] Years later, I heard Hans Israël summarize his investigation. It appeared that the ionizers used by some of the doctors with the most beneficial results did not even contain a high-voltage supply; that is, they did not produce ions at all.

The Negative-Ion Myth

The previous story is a good example of a negative-ion myth. Repeatedly, it has been reported that negative ions are good and that positive ions are bad, usually with little if any scientifically rigorous documentation.

One of the oldest claims concerning the effect of ions is that air rich in negative ions is fresh and that air rich in positive ions is stuffy. Of course, it is difficult to prove or disprove such statements, as freshness and stuffiness are subjective quantities for which there is no physical method of measurement. Therefore, let us be subjective. Let us assume that most people will agree that the air at a mountaintop deserves to be called fresh. Now, it just so happens that this air is rich in positive ions, the concentration being maybe 3–4 times greater than at sea level. The freshness and the positive ions have nothing to do with each other. The freshness could be caused by the air being unpolluted and cool, and the high positive-ion concentration is simply a result of the electrode effect.

Let us also assume that most people will find that during a thunderstorm (before the rain sets in) the air may be considered less than fresh, maybe even stuffy. This same air is rich in negative ions. The stuffiness might be explained by high humidity and other thermophysical factors, and the high negative-ion concentration is simply an effect of the strong negative field from the base of the thundercloud to the ground.

Another example of the negative-ion myth concerns the effects of ions on the cilia in the respiratory tract. From 1957 through 1963, a series of papers were published by Krueger et al., who suggested that air with an excess of positive ions caused a deceleration of cilia activity and of the rate of mucus flow, whereas air with an excess of negative ions produced changes in the opposite direction and reversed the effects of positive ions.[5,6] In other words, exposure to negative ions would increase the rate with which the airways were cleared.

Although other researchers failed to show any effects of unipolar ionized air on cilia frequency and mucus flow, the papers of Krueger et al. were widely quoted; even today, there are still positive references to their work. This is in spite of the fact that, in 1971, Andersen's book *Mucociliary Function in Trachea Exposed to Ionized and Non-Ionized Air* demonstrated without any doubt that the claimed effects do not exist.[7] Andersen gave a very thorough and sober evaluation of all the previous work and pointed out a series of experimental shortcomings that made any conclusion drawn from the results dubious. Andersen also conducted a large experimental study under carefully controlled conditions (thermodynamic, aerodynamic, and electrical) and using modern equipment. He demonstrated that there was no relationship between ion concentration (of either polarity) and cilia frequency. His conclusion was as follows:

> It is concluded that—the application of unipolar or bipolar ionized air in the therapy of diseases in the airways, and active control of ion concentrations in homes and places of work etc. for prophylactic reasons must be considered without any experimental-physiological basis.

Freshness and positive ions have nothing to do with each other.

The Ion-Balance Myth

The ion-balance myth is a special version of the negative-ion myth. The concept of ion balance is not really defined in atmospheric electricity, but it is probably supposed to mean the ratio between the concentrations of negative and positive ions. In a closed room, it is obviously possible to control this ratio by producing an excess of ions of one polarity. However, this is not what is normally meant when references are made to changes in ion balance. It is often claimed that certain procedures or even just certain materials will selectively remove one polarity of ions. Over the years, it has been claimed time and time again that if the ions removed were the negative ions, the result would be a bad ion balance.

In this context, we are talking about naturally occurring ions, that is, ions produced primarily by the decay of airborne radioactive materials. As already mentioned, ions are always produced in pairs; therefore, the production rates for positive and negative atmospheric ions are identical. In the free lower atmosphere, a state of equilibrium will be reached at which the constant production of ions is balanced by positive and negative ions recombining with each other, combining with aerosol particles, or diffusing to ground. The result will be a state with a positive-ion concentration maybe 20–25% higher than the negative one. The difference is caused by the positive ions having a somewhat lower mobility than do negative ions ($1.4 \cdot 10^{-4}$ $m^2V^{-1}s^{-1}$ and $1.8 \cdot 10^{-4}$ $m^2V^{-1}s^{-1}$, respectively). Positive ions therefore also have a lower diffusivity, and this is balanced by a higher concentration of positive ions so that the actual removal rate by diffusion is the same for both positive and negative ions.

The actual values of the ion concentrations depend strongly on the concentration of aerosols or pollutants. In relatively clean air, the concentrations of the ions may be in the hundreds (per cubic centimeter), in highly polluted air, they may be 10 times as low. But the important fact is that the ratio, the ion balance, is almost the same, about 1.2–1.3.

A high level of pollution will turn most of the ions into charged particles, or heavy ions, but with no preference for

either polarity. Since the 1930s, it has been known that the attachment coefficients for negative and positive ions attaching with aerosol particles are almost the same, resulting in a population of aerosol particles divided more or less equally between negative, positive, and neutral particles. This is true with moderate pollution levels. With very high aerosol concentrations, there are not enough ions to charge the aerosol particles, and the neutral particles will dominate.

Evil Winds Are Rich in Positive Ions. It seems reasonably well documented that the hot winds like the Föhn, the Santa Ana, the sirocco, and so forth have a detrimental influence on people's well-being. To explain the special properties of these phenomena, it has often been postulated that the winds, maybe especially the Föhn Alp wind, are rich in positive ions and therefore, according to the negative-ion myth, will feel stuffy and unpleasant. I have never been able to find any hint of a trustworthy theory explaining how a unipolar ionization of the air mass could take place, let alone explain how the charge could be carried hundreds of miles over the mountains without dissipating. I have also not seen any proper scientific papers demonstrating the excess of positive ions in these winds.

Building Materials May Ruin the Ion Balance. Around 1960, a peculiar campaign started in several European countries. The campaign was based on the negative-ion myth. It was claimed that floor coverings of vinyl tiles would ruin the ion balance, meaning that they would create an excess of positive ions, whereas linoleum floors would allegedly leave the ion ratio untouched. No scientific proof for the claim and certainly no measurements were offered, but not a week went by without statements from newspapers, magazines, radio, or television about the harmful effects of vinyl tiles.

A major Danish company that was economically hurt by the campaign asked if the problem could be investigated. I conducted a series of ion-concentration measurements in rooms that were as identical as possible, except that half of the rooms tested had linoleum floors and the other half had vinyl tiles. No significant difference between the two types of rooms could be detected with respect to either the absolute values of the ion concentrations or the ion ratio.

Sick Building Syndrome and the Ion Balance. Over the past 40 years, the interest in the indoor climate has been steadily growing, and in the 1970s, the concept of sick buildings emerged. It appeared that many people felt uncomfortable and maybe even sick when working in certain buildings, especially modern buildings. The symptoms were usually vague, such as headaches, eczema, dry skin, problems with breathing, and so forth.

Many suggestions for the causes were proposed, including mold fungi and dust mites, but both of these causes are connected with inefficient ventilation. It was also suggested that the cause

could be a bad ion balance. Many well-controlled experiments were performed in many different types of buildings. None of the experiments showed any significant deviations from the normal ion-concentration values. Note that there probably is such a thing as a sick building, but it apparently has nothing to do with atmospheric ions.

Positive Ions and Pollution. A peculiar variation of the ion-balance myth has emerged over the past decade. It states that positive ions and air pollution are intimately related; that is, positive ions will preferentially attach to airborne particulates. First of all, this is not true. As already mentioned, the attachment coefficients are very similar for both positive and negative ions. Second, this myth is taken as another proof that positive ions are harmful because they attach themselves to pollutants. If this really were the case, it would mean that polluted air would have an excess of negative ions, as the pollutants would swallow positive ions. However, as already stated, this is not so. Polluted air may have low concentrations of both positive and negative ions.

The examples treated above illustrate rather well a statement made as early as 1985 by Reinhold Reiter, a recognized expert on atmospheric electricity: "Nearly all relevant assertations about harmful or beneficial effects of small ions fail to realize the fundamental elements of atmospheric electricity."[8]

Are Ions Good for You?

So far, the question posed in the title of this article has not really been answered. Instead, discussion has focused on some physical facts and has tried to quench some unfounded myths. Before trying to answer the question, it is important to look at what ions can actually do. Atmospheric ions consist of a nitrogen or oxygen molecule, a few water molecules, and an elementary charge. Human beings are constantly exposed to a mixture of nitrogen, oxygen, and water vapor, so what difference would it make if there were also a positive or negative charge involved?

People in industry, and especially those in the world of electronics, know what it means when a flow of ionized air is directed toward a charged insulator. If the flow is properly balanced, the charge on the insulator can be neutralized because the ions are able to give off their charge. It is the only way that a charged insulator can ever be neutralized.

But what does this have to do with human beings? If a balanced flow of ionized air is directed toward an area of exposed skin, the positive and negative ions will be neutralized when plating out very close to each other, and the result may be some very weak currents on the outer layer of the skin. However, it is a completely different story if a unipolar (say negatively ionized) airflow is used instead. If the person is not grounded, the body will acquire a gradually increasing negative voltage until a discharge, usually a spark, takes place or until the unavoidable leakage current balances the ion current.

The case becomes much more interesting if the person is grounded. Let us suppose that the person is placed on an insulative sheet and that a grounded wrist strap is attached to the right wrist. Now, if a unipolar (say negatively ionized) airflow is directed toward the person's exposed back, the ions will plate out on the skin and be neutralized, and their charge will run through the body to the wrist strap. If this process has an effect, it would not be because of the ions per se. The ions have only served as carriers of the charge to the body. So the questions are "can these currents have any effects?" and "what kind of paths do the currents follow?" I am far from sure that I can answer these questions, but I can tell a story.

Polluted air may have low concentrations of both positive and negative ions.

Unipolar Ionized Air

A few years ago, I was contacted by a Danish architect; let us call him Mr. W. He was very interested in indoor climate and wanted to learn more about ions and their effects on people. Of course, I told him that ions had no (direct) effect on people, but sure, I could teach him something about ionizers for air-cleaning purposes and for neutralizing charges on insulators.

Mr. W believed in the healing effects of (negative) ions. He used unipolar ionizers for treating patients suffering from various ailments and reported surprisingly positive results. I insisted that it was not the ions but their charge that was responsible for any effects. After some pilot laboratory experiments, it was demonstrated that positive and negative ions were equally effective. The flow of unipolar ionized air seemed to be especially effective in healing sores and wounds and in reducing (and not only temporarily) pains and side effects in, for example, cancer patients undergoing chemotherapy or radiation treatment. Mr. W also had some ideas that the method actually was a kind of acupuncture, but in any event, it was definitely an alternative method of treatment.

In the Western world, or at least in Denmark, the established medical society frowns on anything alternative, especially if it contains elements of sciences of which the established medical society has no knowledge and experience—such as physics. So there was no way that Mr. W could have a clinical test of his method performed in Denmark under proper medical supervision. However, in other parts of the world, the attitude to alternative treatment methods is quite different.

At the prestigious Chulalongkorn University Hospital in Bangkok, where acupuncture is a recognized specialty, the chief oncologist, Kris Chatamra, had heard about Mr. W's results and offered to set up a small pilot project as a forerunner for a proper clinical test. The pilot project was conducted in June 2002. Chatamra had chosen four very sick patients for the test: three cancer cases (considered terminally ill) and one patient with a chronic infection (diabetes related) on one foot. All four patients were in severe pain and required regular and strong analgesia.

The patient to be treated was placed on an insulative sheet on a cot, and a wrist or ankle strap was attached to the patient. A flow of unipolar ionized air was directed toward a selected exposed part of the patient's skin. The strap connected the patient to the ionizing

unit through a feedback system, which monitored the ion flow and the total dose. The current to the patient was in the order of μA, and the exposure time was typically 90 minutes. The length of the trial was 10 days. The patients were fully assessed prior to the trial and also assessed daily during the trial by a specialist nurse. Pain assessment was conducted by patient scoring and by the amount of analgesia required daily.

At the end of the pilot project, Chatamra concluded:

> The results are encouraging: All patients required less analgesia (one patient actually stopped taking it altogether). The chronic wound also showed accelerated healing, and the patient is now discharged from the surgical unit. None of the patients suffered any complications.

This was a very small project. It did not prove anything, scientifically speaking. But as Chatamra says, the results are encouraging. A proper clinical test with all the necessary precautions, such as double-blind testing and the use of a control group, is planned.

My role in the pilot project, and maybe in the (hopefully upcoming) clinical test, has merely been that of a physics consultant and observer—an observer who has gradually lost his belief that ions have no effect on human beings. However, to quote Luke 15:7, "There will be more rejoicing in heaven over one sinner who repents." Still, the negative-ion myth and the ion-balance myth are nothing but that, myths.

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